



IIT ROORKEE



NPTEL ONLINE
CERTIFICATION COURSE

MELTING AND CASTING OF CAST METALS

Foundry Practice for Production of Malleable and Ductile Iron

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Ductile Iron

- Advantage of Gray Iron (Low M.P., Good fluidity, excellent machinability, good wear resistance)
- Advantage of steel (High strength, Toughness, Ductility, hot workability and hardenability)
- Matrix of ductile iron can be controlled by base composition, by foundry practice and/or by heat treatment.



DUCTILE IRON



CAST IRON

Solidification of ductile iron

- Solidification is at higher temperature as compared to Gray Iron.
- Magnesium/Cerium/Calcium and Yttrium are used for causing spheroids .
- Generally only 0.05% residual magnesium is necessary to achieve spheroid formation in most ductile irons.
- Nodule counts are directly affected by C content.



- $CE > 4.3$ promotes development and growth of graphite spheroids.
- Si increases amount of ferrite formed during eutectoid transformation and strengthens iron by strengthening ferrite.
- S content after treatment $\sim 0.015\%$
- P adversely affects toughness and ductility (a maximum of 0.05% is usually specified).

Melting

- Basic cupola preferred
- Acid melting cheaper, but not able to remove S easily.
- 0.01% S removal requires 0.1% Mg. Maximum fluidity occurs when pouring temperature is high & composition is eutectic one.
- Hypereutectic Gray Iron: Loss fluidity because of kishing, precipitation of carbon flakes as liquid metal cools.
- Mg first acts as deoxidizer and desulphurization. With residual Mg, graphite spheroids are formed.
- Mg is usually alloyed with other elements to increase its recovery (Mg-Ni alloy, Mg-FeSi alloy, Mg-Si alloy etc)



Methods of Mg treatment

- Open ladle method: Mg alloy kept at bottom of treatment ladle and metal poured over it.
- Sandwich method: Alloy is placed into a recession in the refractory bottom of ladle and covered by steel plate, iron chips, ferrosilicon or an inert material.
- Plunging method: Mg alloy placed into container positioned within a vented graphite or refractory bell fastened to a refractory covered plunging rod
- Mechanical Feeder



Inoculation treatment

- Inoculation or post inoculation treatment is practice of making an addition to the melt which will increase the number of spheroids formed during solidification.
- Fe-Si alloy is the commonly used inoculant.
- Fe-Si alloy (0.5-1.5% Si) is added during inoculation.



Foundry process control

- Green/dry sand mold used
- Moisture content must be carefully controlled (because ductile iron, having been treated with Mg oxidizes easily).
- Pouring practice: pouring temperature more than 1420°C preferred), at low temperature (below 1380°C , oxidation products occur more readily).
- Mg addition increase surface tension compared with gray cast iron, hence sand mold is not easily wetted and burn in and penetration problems are avoided.



Gating design

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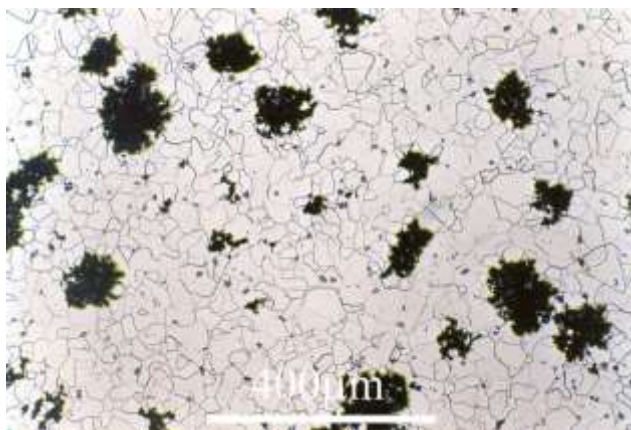
Heat Treatment of Ductile Iron

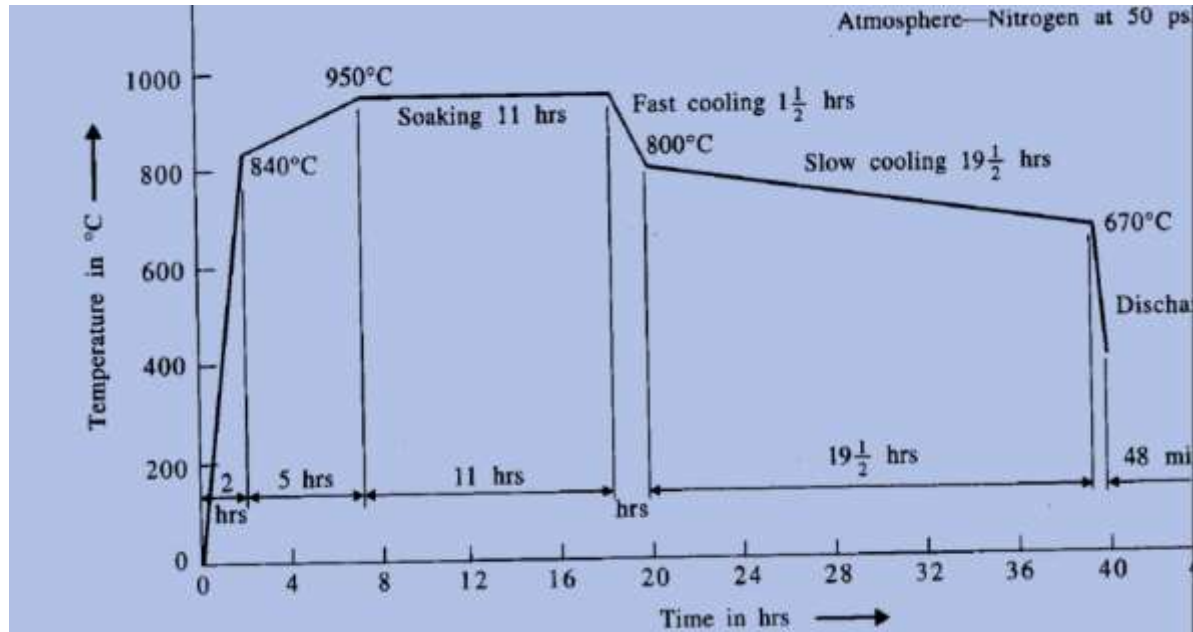
- Annealing (for good ductility and machinability)
(Holding at 900°C for 1 hour or more per inch of section thickness, cooling to 700°C and holding for 5 hours)
- Normalizing (for improvement in T.S.)
- Hardening and tempering
- Stress relief



Malleable Iron

- Type of Iron with Graphite in the form of irregularly shaped nodules
- Produced by first casting the Iron as a White Iron, then heat treating to transform the Carbide into Graphite.
- Has considerable ductility and toughness due to the combination of nodular graphite and low carbon matrix.
- Matrix microstructure depends upon cooling rate.





Annealing cycle for blackheart (ferritic) malleable iron

Steps in annealing

- First step: Nucleation of graphite
- Second step: Elimination of massive carbides (first stage graphitization)
- Third step: Slow cooling through allotropic transformation range (second stage graphitization), formation of completely ferritic matrix



THANKS

